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An air-permeable mattress providing great lying comfort

The invention relates to an air-permeable mattress with great lying comfort and low weight, comprising at least one air-filled pressure cushion, preferably used as a sleeping mattress, whose basic structure allows an especially favorable air circulation and thus a removal of humidity secreted by the person lying on the same and offers an especially great lying comfort, whose pressure hardness is adjusted to the body zones and can be adjusted individually to the requirements of the person lying on the same, even when the needs are subjected to individual fluctuations or changes such as in the case of being bedridden for a prolonged period after illness or accident, and which further has a low weight and is completely free from metallic components.

Numerous efforts have been made to increase the comfort of sleeping mattresses and to meet the new requirements.

Conventional "pocket-sprung mattresses" for example offer the highest possible degree of air permeability and thus the ability to convey humidity secreted by the human body during the sleep phase away from the body through the mattress, so that even at higher transpiration as a result of higher ambient temperatures the mattress surface in contact with the human body seems to be dry. The fact is regarded as a serious disadvantage for "pocket-sprung mattresses" that the spring elements are principally made up of metal wire. Current requirements demand a metal-free configuration. A further disadvantage is that the spring characteristic and thus the spring properties of the mattress can no longer be changed retroactively, which is why sleeping mattresses which are thus configured cannot be adjusted to the individual requirements of the sleeping person. Mattresses with different spring characteristics (mattress hardness) are available for the different weights of the persons.

New requirements are met by industry with new embodiments. They are capable however of always covering only individual requirements, but are unable to fulfill all relevant needs.

One measure for increasing the lying comfort and for considering different hardness zones was tried by providing a system of helical springs of glass fiber material which were inserted into tubular recesses, were aligned transversally to the body axis, and were arranged approximately in the center of the mattress thickness and assumed approximately the entire width of the mattress. The basic material of the mattress consists of foamed material and the diameter of the tubular recesses is approx. $1/3$ to $1/2$ of the thickness of the mattress. In this embodiment which is known as "aurora system", there is a serious disadvantage in the respect that as a result of the closed foam core structure which does not allow sufficient air circulation in the direction of thickness of the mattress, the removal of humidity secreted by the lying person is insufficient. Moreover, the cushioning comfort cannot be changed retroactively in this embodiment.

Further embodiments replace metallic springs by a system of air chambers. Several air chambers are provided in such systems which are associated with the different mattress regions and thus allow achieving different hardness zones. These include, among others, the three-zone air bed of EP 0 992 206 A1 and an air-bed frame design of EP 1 093 739 A1 for a mattress system designated as "air bed" which is additionally equipped with electric and electronic components for air pressure monitoring and display and for air pressure generation by means of electric air pump. Further embodiments with six air chambers or with 10 air chambers such as the mattress system designated as "air touch" round off these mattress systems. The fundamental structure of the mattresses is principally disadvantageous in all these systems, which is characterized in that these air chambers assume in total virtually the entire lying area and thus an air circulation and a removal of secreted bodily humidity of the lying person is not possible through the mattress. A further disadvantage relates to the use of metallic components, electronics, electrically operated air pumps and display devices.

A further known embodiment of a mattress with air chambers consists of a single air chamber whose filling is achieved with a special manually actuated air pump integrated in the bordering of the mattress and is actuated under load as a result of a displacement of the body weight. The air pressure built up in the air chamber can be changed by means of a continuously adjustable valve. This embodiment makes do without any electronic components and without any

metallic components, but comes with the known disadvantage of prevented air circulation and thus a prevented removal of secreted body humidity.

Further embodiments relate to foam core mattresses where it is tried, through a combination of different patterns and variants in the foamed materials with different degrees of hardness, to achieve different pressure resistances in the individual lying regions. Considering all possible imagination in the pattern configuration and choice of foamed materials, a sufficient air circulation and removal of secreted body humidity is only possible to an only very limited extent in closed foam core mattresses, and the lying comfort and the cushioning behavior cannot be changed.

US Pat. No. 6,487,739 B1 shows a multi-layer mattress which comprises an air cushion layer with a plurality of so-called "air cells" according to Fig. 1 for example. The air circulation of this mattress is produced with a special air pump and occurs via the free intermediate spaces between the supporting air chambers. However, an airing from the upper side to the lower side of the mattress is missing because the same would be interrupted by layers situated below in the embodiment according to US Pat. No. 6,487,739 B1. Moreover, the mattress does not comprise a foam core.

EP 0 453 363 A1 discloses a mattress with spring elements and air chamber elements which each extend over one half in the central region of a double-bed mattress. The two lying sides can be brought to a different filling pressure and the lying comfort can be adjusted individually. The mattress does not comprise a foam core however.

It is known from CH 687 806 A5 to provide a plurality of different individual chambers in a mattress, which chambers comprise at least one compensation chamber on the floor side. The carrier cells can be filled with a gaseous medium and communicate with the compensation chamber via through holes (cf. Fig. 3 of CH 687.806 A5). The mattress neither comprises a foam core nor the required airing which is directed from the upper side to the lower side of the mattress. As a result, there is no possibility whatsoever to remove humidity secreted by the body in a direction normal to the mattress surface.

A mattress is finally known from US Pat. No. 5,907,878 A which consists of a plurality of air spring elements which are joined by means of an air-tight carrier layer. The air-tight carrier layers prevent air permeability transversally through the mattress. Moreover, there is no foam core which should exert a carrying and supporting function.

It is the object of the present invention to provide a mattress which offers the highest amount of lying comfort, allows a pressure hardness adjusted to the body zones and can be adjusted individually to the requirements of the person lying on the same, even when the needs are subjected to individual fluctuations or changes such as in the case of being bedridden for a prolonged period after illness or accident, allows an especially high amount of air circulation and thus the possibility to remove secreted bodily humidity of the lying person through the thickness of the mattress, and which further has a low weight and is completely free from metallic and electronic components.

This object is achieved in accordance with the invention in such a way that the mattress consists of a combination of a foam core and air-filled pressure cushion(s), which are either arranged in openings of the foam core or enclose the same, and that for removing humidity through holes are provided in the foam core and/or in the pressure cushions.

The mattress in accordance with the invention thus consists of a foam core which is provided with a plurality of bore holes which penetrate the thickness of the mattress, with said bore holes being filled with air chambers or pressure cushions which can again be configured as hollow bodies and can be joined with each other by means of transversal connections in such a way that air can be exchanged in an unhindered manner in this system of air chambers. These air chambers are joined with each other in zones (preferably three to seven zones), so that different pressures adjusted to the body zones can be built up. A special air valve is provided for each of the zones, with the help of which the pressure in the air chambers can be limited individually. A special apparatus is integrated which is configured as a pneumatic pump, with the help of which leakage losses by escaping air can be compensated and an increase in the pressure in the system can be made. A pressure relief valve prevents any bursting of the air chambers in the case of an inadvertent overloading of the system.

In an especially preferable embodiment, the entire surface of the basic body of the foamed material including the surface of the through holes is covered with a layer of air-impermeable material. An especially large air chamber is thus formed which is filled with foam material. The air chamber and the foam material are compressed under load, the volume in the air chamber is reduced and a higher pressure level is built up. After relaxing, the foam material assumes its original shape again. The volume in the air chamber is enlarged again and the increased pressure degrades. Any leaked air can automatically be refilled again (sucked in) by means of a special valve, which is configured as a non-return valve, when the air chamber assumes the maximum volume again and a negative pressure is produced in the interior as a result of a preceding air loss and ambient air with a higher pressure level flows through the valve into the interior until an approximate pressure balance is achieved.

The upper side of the mattress is provided with a support layer made of a material which can transport humidity especially well and is made of an antibacterial material. The bottom side of the mattress consists of a layer which is especially air-permeable. Side elements made of a foam material with a higher pressure hardness are provided on the side, so that persons are able to support themselves better on the side if necessary.

As a result of the continuous openings in the mattress body, an unhindered air circulation and a transport of secreted body humidity through the mattress are possible, even in the case of higher transpiration as a result of increased ambient temperatures.

The pressure behavior and the individual pressure distribution are relevant for the lying comfort, in addition to the capability of unhindered air circulation in the mattress.

A further advantage is obtained from the reduction of the share of material due to the continuous transverse holes, leading to a reduction in weight.

The excess system pressure in the pressure cushions 5 can be between 0.1 bar and 0.6 bar, preferably between 0.15 bar and 0.30 bar.

The invention is explained in closer detail by reference to the embodiments shown in the drawings.

Fig. 1 shows an embodiment in accordance with the invention of a mattress with a foam core 1, side parts 2a, 2b and tubular air chambers 5 and through holes 6, with the upper support layer 3 having been removed for the purpose of clearer illustration;

Fig. 2 shows a sectional view of the mattress according to the embodiment of Fig. 1 along the line of intersection I-I;

Fig. 3 shows an oblique view in an exploded representation.

Fig. 4 shows an embodiment of a pressure cushion or an air chamber 5, configured as a tubular hollow body in an oblique view.

Fig. 5 shows an embodiment of a pressure cushion or an air chamber 5, configured as a solid cylinder in an oblique view. In this embodiment, air circulation is only possible through additional openings outside of the pressure cushion or air chamber 5.

Fig. 6 shows a further embodiment of a pressure cushion or an air chamber 5 with an opening 6 for the air circulation, made up of several superimposed, mutually joined segments of preferably toroidal hollow bodies comprising inner connecting openings for pressure compensation, in a projection;

Fig. 6a shows the same embodiment in a sectional view along the line of intersection I-I according to Fig. 6;

Fig. 6b shows a detail X of the pressure body according to Fig. 6a;

Fig. 7 shows the pressure cushions or air chambers 5 according to Fig. 4 with connecting elements in a row, preferably configured as tubular connections 7 between the individual pressure cushions or air chambers 5 which are combined to one zone each and have a uniform pressure level, in an oblique view;

Fig. 8 shows the pressure cushions or air chambers 5 according to Fig. 4 with connecting elements 7, 8 which are arranged in a cross-wise manner and are preferably configured as tubular connections between the individual pressure

cushions or air chambers which are combined into a zone each and have a uniform pressure level, in an oblique view;

Fig. 9 shows the pressure cushions or air chambers 5 according to Fig. 5 with connecting elements in a row, preferably configured as tubular connections 7 between the individual pressure cushions or air chambers which are combined into a zone each and have a uniform pressure level, in an oblique view; Fig. 10 shows a top view of an embodiment of a mattress core 1 with through holes for receiving the pressure cushion or air chambers 5 and additional through holes 6 for a sufficient air circulation;

Fig. 11 shows a top view of a preferred embodiment of a mattress core 1, made up of two layers of foam material 1', 1" with different degrees of hardness, with continuous openings for receiving pressure cushions or air chambers 5;

Fig. 11a shows a sectional view of the mattress core along the line of intersection II-II according to Fig. 11;

Fig. 12 shows an oblique view of an embodiment of a mattress in accordance with the invention, configured to offer optimal lying comfort. This embodiment is provided with additional devices which allow an individual regulation of the lying comfort. Pressure regulating devices are provided for this purpose which allow individual pressure levels in the pressure cushions or pressure chambers combined into a zone each. At least one zone is provided, but preferably three zones, offering medium pressure resistance for the body zones of head, neck and shoulders, high pressure resistance for the trunk, and medium pressure resistance for lower leg and foot, or five zones, offering medium pressure resistance for the body zones of head and neck, lower pressure resistance for the shoulders, high pressure resistance for the trunk, low pressure resistance for the lower leg and medium pressure resistance for the foot (see Fig. 12a).

An especially preferred embodiment of a mattress in accordance with the invention is shown by Fig. 13 in a top view and Fig. 13a in a sectional view along the line of intersection IV-IV according to Fig. 13. In this embodiment, the entire mattress surface including the surface of the continuous through holes is covered with an air-impermeable layer 10. A favorable influence of the cushioning behavior is given by additional cylindrical insert bodies 11 which consists of

especially large-pore foam material and substantially fill the through holes 6 and is shown in Fig. 13b. A sectional view along the line of intersection V-V of this embodiment is shown in Fig. 13c.

Fig. 14 shows a further variant of a mattress in accordance with the invention in a exploded view. In this embodiment, which is configured for the highest possible lying comfort, the pressure cushions or air chambers 5 consist of solid cylinders which are arranged transversally to the longitudinal axis of the mattress in openings 1d in the mattress core and lie parallel with respect to each other.

Fig. 15 shows the preferred embodiment of a double mattress in an oblique view.

The mattress according to the embodiment according to Figs. 1 to 3 and Figs. 10 to 13 has a length L, a width B and a total height H. The mattress according to Fig. 15 (double mattress) has a total width of $2 \times B$. The mattresses are principally made up of a core 1 made of foam material, the side parts 2a, 2b made of foam material with a higher pressure hardness, an upper support layer 3 made of an especially air-permeable and hydrophobic material, preferably with antibacterial properties, and a bottom support layer 4 made of air-permeable material. A high air circulation is enabled by means of a plurality of openings 6 which penetrate the height of the core 1 of the mattress, which circulation ensures a transport of secreted bodily humidity through the mattress. The preferred direction of transport 6a of bodily humidity is directed downwardly away from the body, through the mattress. For the purpose of increasing the lying comfort, the pressure resistance which the mattress exerts on the person lying on the same is influenced by suitable measures in addition to air circulation. The entire mattress is provided with a cover (not shown here in closer detail), preferably made from a preferably antibacterial textile material which provides the mattress, among other things, with the required cohesion.

In a first embodiment according to Fig. 1 to Fig. 3, tubular pressure cushions/air chambers 5 are provided for achieving a high lying comfort, which cushions/chambers are incorporated in through holes 1d in the mattress core 1 and comprise a free through hole 6 to ensure sufficient air circulation and removal of secreted bodily humidity of the person lying on the mattress. The height of the pressure cushion/air chamber corresponds to the height of the

mattress core, preferably in a range of 100 mm to 250 mm. The outside diameter of the pressure cushions/air chambers corresponds to the diameter of the openings 1d, preferably in a range of 30 mm to 100 mm. Another relevant aspect for achieving a high lying comfort is further the possibility to exert different pressure resistances against the individual regions of the body. This is achieved in such a way that the individual pressure cushions/air chambers 5 are combined into zones and each zone can be associated with an individual pressure hardness. Preferably, in the embodiment with three zones, the zone A which corresponds to the head, neck and shoulder region is associated with a lower pressure hardness, the zone B which corresponds to the heavy trunk region is associated with a higher pressure hardness, and the zone C which corresponds to the lower leg and foot region is associated with a lower pressure hardness. In the variant with five zones and three pressure levels, zone A1 which corresponds to the head and neck region is associated with a medium pressure hardness, zone C1 which corresponds to the shoulder region is associated with a low pressure hardness, zone B which corresponds to the trunk region is associated with a high pressure hardness, the zone C2 which corresponds to the lower leg region is associated with a low pressure hardness, and zone A2 which corresponds to the foot region is associated with a medium pressure hardness. Different pressure hardness/pressure resistance can be achieved in different ways. In the case of approximately equal pressure conditions in the pressure cushions/air chambers 5, different distances of the pressure chambers/ air cushions from one another cause a different pressure resistance of the person lying on the same. A comparable result can also be achieved when the pressure cushions/air chambers 5 are associated with different pressures in a zone by zone manner. A further possibility consists in the combination of the first two variants.

An air circulation is enabled by a tubular structured pressure cushion 5 according to Fig. 4 and Figs. 6 to 6b. In the embodiment according to Fig. 4, the pressure cushion 5 is made of air-impermeable film material and consists of an outer cylinder and an inner cylinder 6 and an upper and bottom sealing element. A "tubular" pressure cushion is thus formed, once air is filled into the chamber with a pressure level above atmospheric air pressure. Air circulation 6a is enabled without any obstructions by the inner opening 6. The height of the pressure cushion corresponds to the height of the mattress core 1 and the outside

diameter corresponds to the diameter of the openings 1d in the mattress core. In the embodiment according to Fig. 6 through Fig. 6b, the pressure cushion is made of several, preferably 2 to 6 individual chambers 5a which are arranged above one another and are joined to each other in such a way that as a result a pressure-tight pressure cushion is formed, comprising inwardly situated openings 5b allowing an air transport 5c from an individual chamber to the other and thus a pressure compensation in the pressure cushion 5. The outside diameter D corresponds to the diameter of the opening 1d in the mattress core 1. The inner opening 6 is provided for the air circulation.

In a further embodiment of a pressure cushion according to Fig. 5, additional openings 6 according to Fig. 10 are required for the air circulation 6a in the mattress core. The pressure cushions 5 are configured as solid cylinders in this embodiment. The diameter and the height correspond to the embodiments according to Fig. 4 and Fig. 6.

Several pressure cushions 5 are principally combined into a zone (e.g. A), with the lying surface of the mattress being divided in total into one single zone or several zones according to Fig. 3, preferably into three to five zones. The pressure cushions/air chambers have a uniform pressure level within one zone. This is achieved in such a way that the individual pressure cushions/air chambers 5 according to Figs. 7, 8 or 9 are joined to each other in a linear or cross-wise manner by means of special connecting elements in such a way that a transport of air from one pressure cushion/air chamber 5 to the next is possible in an unhindered manner and thus a pressure compensation is achieved within the pressure cushions/air chambers 5 combined into a zone A, B, C. These connecting elements 7, 8 are preferably arranged on the lower side of the mattress, i.e. the side averted from the lying surface 3.

The foam core 1 of the mattress is configured in an especially preferred embodiment in a manner consisting of several parts, preferably two parts. In accordance with the embodiment according to Fig. 11 and Fig. 11a, the mattress core consists of two layers of foam material 1', 1'' of different hardness, with the bottom layer 1'' preferably consisting of a foam material of higher hardness. The cushioning properties and the lying comfort can thus be further influenced in a positive manner.

A further especially preferred embodiment of a combined foam-material and pressure-cushion mattress is composed in its entirety of a single pressure cushion or air chamber 5, or of a pressure cushion or air chamber 5 for each zone. In this embodiment according to Fig. 13 and Fig. 13a, the mattress structure consists of the mattress core 1 made of foam material which is provided with a plurality of openings 6 for the air circulation 6a. and an air-tight cover 10 made of film material for example, with the entire surface being covered in an air-tight manner with this cover, which also includes the walls of the opening 6. The mattress core must fulfill two tasks, on the one hand to support the overall pressure resistance of the mattress and on the other hand to compensate the deformation of the mattress again after a pressure load and to bring the air-tight cover 10 back to its original shape again at the same time and to increase the volume in this process. Under the pressure load the volume of the air-tight cover forming a pressure cushion or air chamber 5 is reduced and the internal pressure is increased. In order to prevent that the inner wall of the through holes 6 will bulge under the pressure load and that an undefined low pressure state would occur, especially air-permeable foam cylinders 11 are provided for a modified embodiment, which cylinders are pushed into the through holes and fill a large part of the volume of the through hole 6. Leakage losses are compensated after the expansion of the mattress by means of a non-return valve. A subdivision of the lying surface into individual zones or a zone by zone adjustment of the pressure resistance is provided by means of individual distances and magnitude of the through holes.

It is provided for increasing the lying comfort to divide the lying surface into several zones, preferably three zones, which can be associated to the body zones and set different pressure resistances. Special metal-free pressure control valves are provided for this purpose which can be regulated in a continuous manner and are arranged on the side or the foot end of the mattress. A system pressure is preset with this pressure control valve which under load corresponds to the maximum pressure resistance. A mattress with a division into three zones A, B, C is shown in Fig. 12. A pressure control valve each is associated to the three zones. Fig. 12a shows an embodiment with five zones A1, C1, B, C2, A2 and three pressure control devices. Leakage losses are compensated by means of an integrated air pump 12. This air pump is preferably integrated in the base of the

mattress and, after a shift of weight of the person lying on the mattress, pumps under load a compressed air volume from the pump body into the pressure cushions or air chambers 5 up to the preset maximum pressure via air lines 15 through pressure control valve 14a, 14b, 14c in the controller unit 13. A pressure relief valve prevents any rupturing of the pressure cushions/air chambers as a result of overload for example.

Fig. 14 shows a further embodiment of a mattress with an especially high claim to lying comfort, by simultaneously offering favorable aeration. Several pressure cushions/air chambers 5 are arranged transversally to the longitudinal axis of the mattress and parallel to the lying surface in openings 1d of the mattress core 1. They are configured as solid cylinders. There is a defined intermediate space between adjacent pressure cushions/air chambers 5, which intermediate space allows an air circulation through the thickness of the mattress. This air circulation is achieved on the one hand by the air-permeable foam material of the mattress core and can be supported by additional openings 6 which penetrate the mattress through its thickness. The natural air circulation and the transport of humidity are supported by additional openings 6a which are arranged parallel to the lying surface and which penetrate the width of the mattress. It is provided for alternatively that warm air is transported for the purpose of heating the mattress or cold air for the purpose of cooling the mattress during the hot seasons by means of a blower device (not shown) through openings 6a situated transversally to the same. The transversal pressure cushions/air chambers 5 can be subjected to different pressures and can be subdivided into several zones. Three, six or seven zones can be appropriately distinguished depending on the subdivision. It has proven to be especially appropriate to provide a middle zone D with a higher pressure resistance as lordosis support, two especially soft zones C1 and C2 for the shoulder and knee region, two zones of medium hardness B1 and B2 for the trunk and pelvic region, and two further zones A1 and A2 for the head and foot region. The individual pressures can be adjusted individually by the lying person by means of simple, preferably metal-free control valves. The compensation of leakage losses and pressure increases are possible by means of an air accumulator which is filled automatically in case of any major shifting of weight.

The application thus substantially comprises the following main variants and sub-variants:

- A mattress with a plurality of tubular air cushions 5 in a foam core mattress 1, with through holes 6 being formed in the tubular air cushions 5 (cf. Fig. 3 for example). There is a sub-variant in connection with this in which the tubular air cushions are composed of toroidal individual rings (cf. Fig. 6a for example).
- A mattress with a plurality of cylindrical air cushions 5 which are arranged in openings of the foam core 1, with the through holes 6 in the foam core 1 being arranged adjacent to the air cushions 6 (cf. embodiment of Fig. 10 for example).
- A mattress in which the entire foam core 1 or partial regions thereof are arranged in the air cushion 5 (in the air-tight cover 10) and the through holes 6 are guided through the air cushion 5 and the foam core 1 arranged therein (cf. Fig. 13a for example).
- A mattress with a plurality of cylindrical air cushions 5 in a foam core 1 which are arranged transversally to the longitudinal axis and parallel to the lying surface, with openings 6' being provided which are arranged parallel to the lying surface and penetrate the width of the mattress.

Double mattresses according to Fig. 15 are principally composed of individual mattresses 1 and glued together by means of special connecting elements 15a, 15b, such that a glued connection over a large surface with shearing strain is enabled and only a small remaining surface remains as a blunt glued point 15c which only needs to fulfill subordinate strength requirements. The main stress forces during the transport or during a usual load are absorbed by the connecting elements under shearing strain. The same embodiments are provided for double mattresses as for single mattresses. Individual lying comfort is guaranteed by means of pressure control valves provided for each side of the mattress.